Biomass Gasification in a Bubbling Fluidized Bed Reactor

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ABSTRACT

The effect of secondary air flow rate and particle size on the combustion temperature inside the bubbling fluidized bed reactor was reviewed. The experiments were carried out for four particle sizes with varied secondary air flow rates. From the results it was evident that the secondary air flow rate has a larger impact on the temperature of the freeboard zone. The temperature profiles show that a maximum temperature is achievable when the magnitude of the secondary air flow rate is lower than that of the primary air flow rate. It was concluded that desired maximum temperature can be achieved regardless of the particle size through the optimum secondary air flow rates for each particle size.

Keywords: Fluidized bed; Sawdust fuel; Gasification; Secondary air flow; High Combustion Efficiency

INTRODUCTION

When considering biomass as an energy source, the basic conversion of energy is from chemical energy to thermal energy. Basically biomass captures energy from sunlight and ambient CO2 which is converted to other fuels like biofuels and synfuels or is used directly as a source of thermal energy or hydrogen.

Objective of the research was to find the optimum secondary air flow rate and particle size that maximizes the temperature inside the bubbling fluidized bed reactor. Furthermore, it was expected to propose a mathematical model for optimization. Existing gap between the available research studies and this research is identified according to the main objective of the research project. This research project will be highly important in identifying suitable energy sources for Sri Lanka.

METHODOLOGY

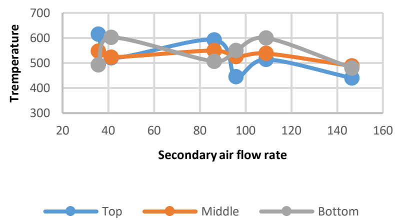
First, a proximate analysis was done to the sample of sawdust and the moisture content and the volatile matter content were identified. A sieve analysis was done to identify the particle distribution of the sawdust sample used. From the same analysis, 4 different particle sizes were identified. The particle sizes selected and the codes given were, 2.80mm-2.00mm (size 1), 2.00mm-1.40mm (size 2), 1.40mm-0.85mm (size 3), 0.85mm-0.60mm (size 4).

Then, a specific particle size was selected to be used in fluidizing the bed. Then the bed was prepared and the primary air flow was given. The control was done through two ways; blower air control and the control valve. After few attempts bed was fluidized in a satisfactory way.

Saw dust was dried in an oven to remove the moisture. Saw dust particles were mixed with an ample amount of kerosene to initiate the combustion. The bed was fluidized using only the primary air flow before ignition. Once the ignition was given the secondary air flow was supplied.

After setting bed into fluidized stage, flow velocity of primary blower was measured. After the combustion started, secondary air flow was opened and flow velocity of secondary flow was measured.

Highest reaching temperatures were measured at the top, bottom and middle of the gasifier. By keep watching the continuous growth of temperature readings in RTD, peak temperature was identified by the time it starts decreasing the temperature values. At the same time readings of rest of the two places were noted.



RESULTS AND DISCUSSION

From the 28 experiments that were carried out, results were obtained and the results analysis was done according to two ways.

1. Temperature variation with secondary air flow rate for each particle size. (making particle size a constant)
2. Temperature variation with particle sizes. (by mitigating the effect of secondary air flow rate)

<u>Temperature variation with secondary air flow rate</u>

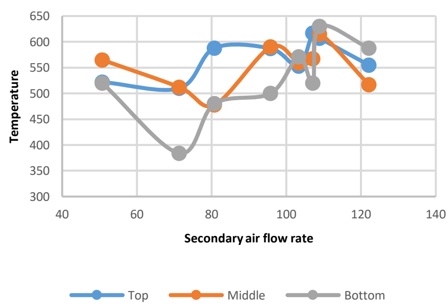


Figure 4 - Particle size 1-Variation with secondary flow

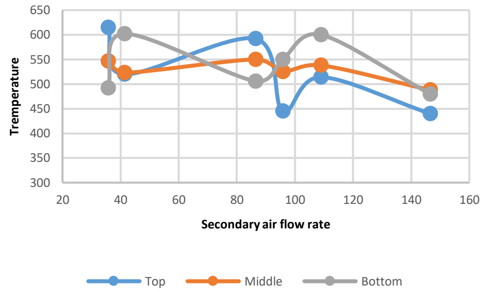


Figure 5- Particle size 2 - Variation with secondary flow

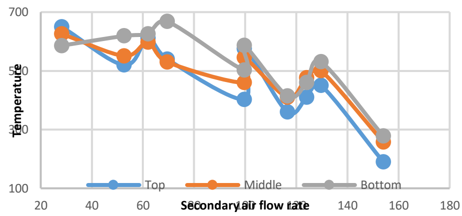


Figure 6-Particle size 3 - Variation with secondary flow

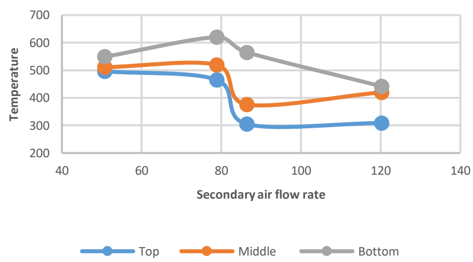


Figure 7-Particle size 4 - Variation with secondary flow

<u>Temperature variation with particle size</u>

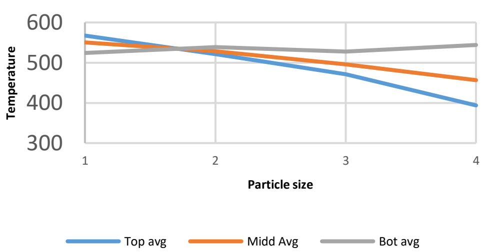


Figure 8- Variation of temperature with particle size

It can be observed that the temperature inside the gasifier reaches a maximum at some point of the varying secondary air flow rate which indicates that just increasing the secondary air flow rate will not result in increased temperatures for sawdust. The temperature inside the gasifier starts at a lower temperature and increases to a maximum with increasing secondary air flow rate and starts to drop much lower with further increments of secondary air flow rate. According to the observations of all the other particle sizes it can be predicted that the temperature will start to drop when the secondary air flow rate exceeds the primary air flow rate. This may be due to the high secondary air flow disturbing the fluidization of the bed and acting as barrier for the bed to rise above that injection point. It can be observed that a sudden drop of temperature has occurred when the secondary air flow rate is slightly below the measured primary air flow rate. Furthermore, the maximum temperature for all the particle sizes has occurred just before this sudden drop of temperature.

When considering the temperature profiles for different particle sizes the largest particle size has shown a maximum which indicates that the larger particle sizes tend to have less effect on fluidization due to the secondary air flow. The smaller particle sizes will be interrupted from the secondary air flow and hence will not be fluidized within the gasifier as wished.

CONCLUSION

It is obvious that both the particle size and secondary air flow rate has a large impact on the combustion temperature of the gasifier from the experimental results. Therefore, it can be concluded that there is an optimum secondary air flow rate for each particle size and all the particle sizes have been able to achieve maximum temperatures nearing 650^0C except for the smallest size which is due to the secondary air flow rate being too high for the size of the particles. When considering the average temperatures inside the gasifier with the varied particle sizes it is evident that the larger particle sizes achieve a higher combustion temperature in the freeboard zone with proper secondary air injection.

REFERENCES

K. V. N. Srinivasa Rao, G. V. (2008). Effect of secondary air flow rate on combustion efficiency of saw dust in a fluidized bed combuster. *Brazilian journal of chemical engineering*.

Leckner, A. G.-B. (2010). Modeling of biomass gasification in fluidized bed. *Progress in Energy and Combustion Science*.

Ramin Radmanesh, J. C. (2006). Biomass Gasification in a Bubbling Fluidized Bed reactor. *ENVIRONMENTAL AND ENERGY ENGINEERING*.

S.Rao, V. (2007). Effect of Secondary Air injection on the combustion efficiency of Sawdust in a fluidized bed combuster. *Brazillian journal of Chemical Engineering.*